BGP Multihoming

ISP/IXP Workshops

Why Multihome?

- **Redundancy**

  One connection to internet means the network is dependent on:

  Local router (configuration, software, hardware)

  WAN media (physical failure, carrier failure)

  Upstream Service Provider (configuration, software, hardware)

Why Multihome?

- **Reliability**

  Business critical applications demand continuous availability

  Lack of redundancy implies lack of reliability implies loss of revenue

Why Multihome?

- Supplier Diversity
  - Many businesses demand supplier diversity as a matter of course
  - Internet connection from two or more suppliers
    - With two or more diverse WAN paths
    - With two or more exit points
    - With two or more international connections
    - Two of everything

Why Multihome?

- **Not really a reason, but oft quoted…**
- **Leverage:**

  Playing one ISP off against the other for:

  Service Quality

  Service Offerings

  Availability

Why Multihome?

- **Summary:**
  - Multihoming is easy to demand as requirement of any operation
  - But what does it really mean:
    - In real life?
    - For the network?
    - For the Internet?
  - And how do we do it?

Multihoming Definition

- More than one link external to the local network
  - two or more links to the same ISP
  - two or more links to different ISPs
- Usually two external facing routers
  - one router gives link and provider redundancy only

Multihoming

- The scenarios described here apply equally well to end sites being customers of ISPs and ISPs being customers of other ISPs
- Implementation detail may be different

end site → ISP	ISP controls config
ISP1 → ISP2	ISPs share config

AS Numbers

- An Autonomous System Number is required by BGP
- Obtained from upstream ISP or Regional Registry (RIR)
  - AfriNIC, APNIC, ARIN, LACNIC, RIPE NCC
- Necessary when you have links to more than one ISP or an exchange point
- 16 bit integer, ranging from 1 to 65534
  - Zero and 65535 are reserved
  - 64512 through 65534 are called Private ASNs

Private-AS – Application

- Applications

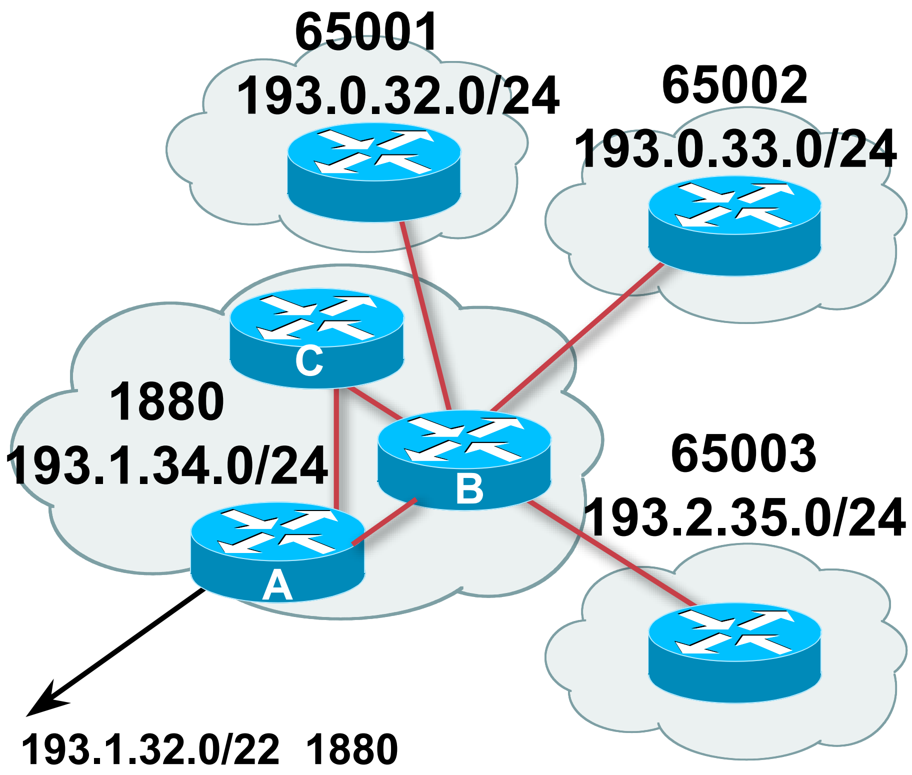
  An ISP with customers multihomed on their backbone (RFC2270)

  -or-

  A corporate network with several regions but connections to the Internet only in the core

  -or-

  Within a BGP Confederation



Private-AS – removal

- **Private ASNs MUST be removed from all prefixes announced to the public Internet**
  - Include configuration to remove private ASNs in the eBGP template
- **As with RFC1918 address space, private ASNs are intended for internal use**
  - They should not be leaked to the public Internet
- **Cisco IOS**
  - neighbor x.x.x.x remove-private-AS

Configuring Policy

- **Assumptions:**
  - **prefix-lists are used throughout**
  - **easier/better/faster than access-lists**
- **Three BASIC Principles**
  - **prefix-lists to filter prefixes**
  - **filter-lists to filter ASNs**
  - **route-maps to apply policy**
- **Route-maps can be used for filtering, but this is more “advanced” configuration**

Policy Tools

- **Local preference**
  - **outbound traffic flows**
- **Metric (MED)**
  - **inbound traffic flows (local scope)**
- **AS-PATH prepend**
  - **inbound traffic flows (Internet scope)**
- **Communities**
  - **specific inter-provider peering**

Originating Prefixes: Assumptions

- **MUST** announce assigned address block to Internet
- MAY also announce subprefixes – reachability is not guaranteed
- Current RIR minimum allocation is /21

  Several ISPs filter RIR blocks on this boundary

  Several ISPs filter the rest of address space according to the IANA assignments

  This activity is called “Net Police” by some

Originating Prefixes

- **Some ISPs publish their minimum allocation sizes per /8 address block**

  AfriNIC: www.afrinic.net/docs/policies/afpol-v4200407-000.htm

  APNIC: www.apnic.net/db/min-alloc.html

  ARIN: www.arin.net/reference/ip_blocks.html

  LACNIC: lacnic.net/en/registro/index.html

  RIPE NCC: www.ripe.net/ripe/docs/smallest-alloc-sizes.html

  Note that AfriNIC only publishes its current minimum allocation size, not the allocation size for its address blocks

- **IANA publishes the address space it has assigned to end-sites and allocated to the RIRs:**

  www.iana.org/assignments/ipv4-address-space

- **Several ISPs use this published information to filter prefixes on:**

  What should be routed (from IANA)

  The minimum allocation size from the RIRs

“Net Police” prefix list issues

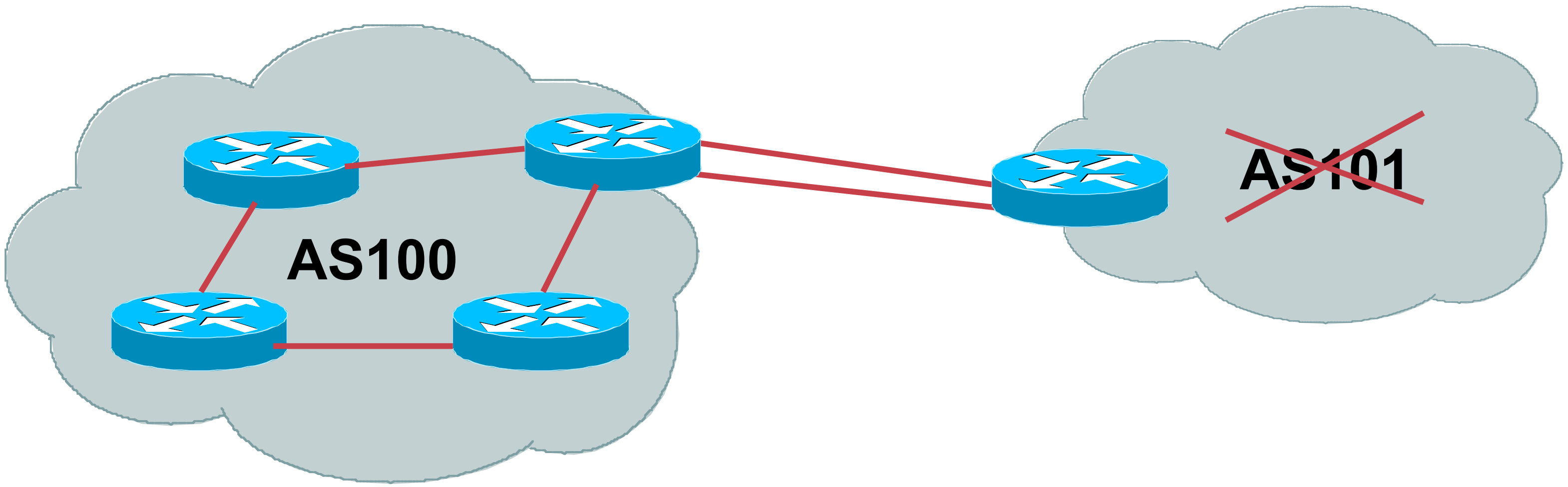
- meant to “punish” ISPs who pollute the routing table with specifics rather than announcing aggregates
- impacts legitimate multihoming especially at the Internet’s edge
- impacts regions where domestic backbone is unavailable or costs $$$ compared with international bandwidth
- hard to maintain – requires updating when RIRs start allocating from new address blocks
- don’t do it unless consequences understood and you are prepared to keep the list current

Multihoming Options

Multihoming Scenarios

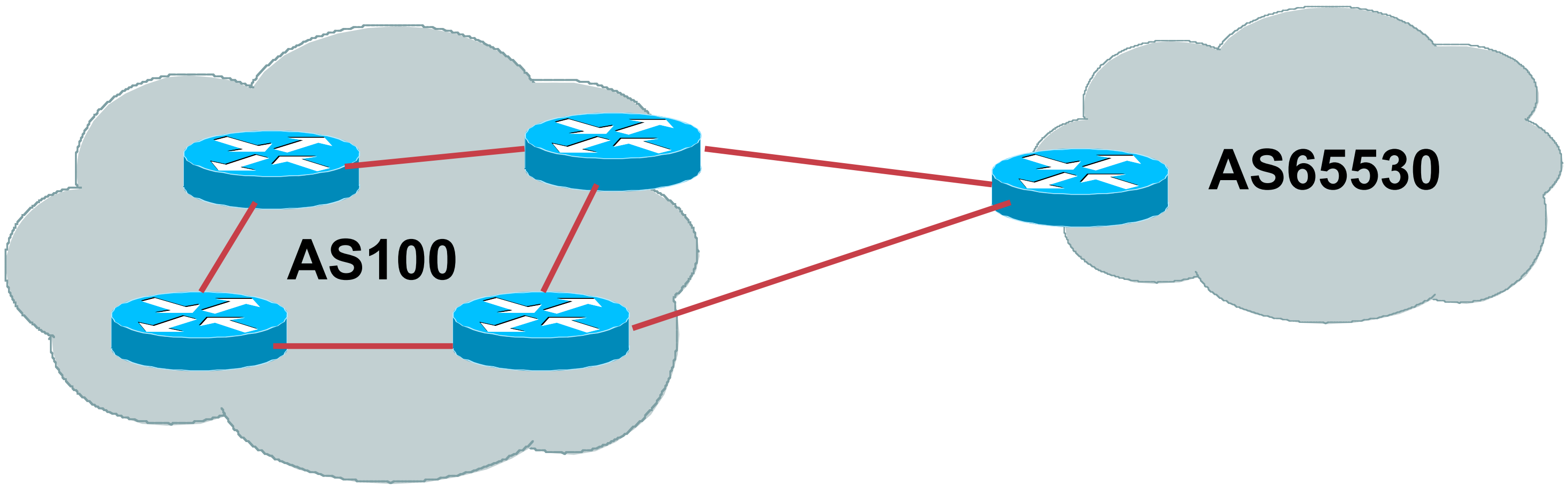
- Stub network
- Multi-homed stub network
- Multi-homed network
- Configuration Options

Stub Network



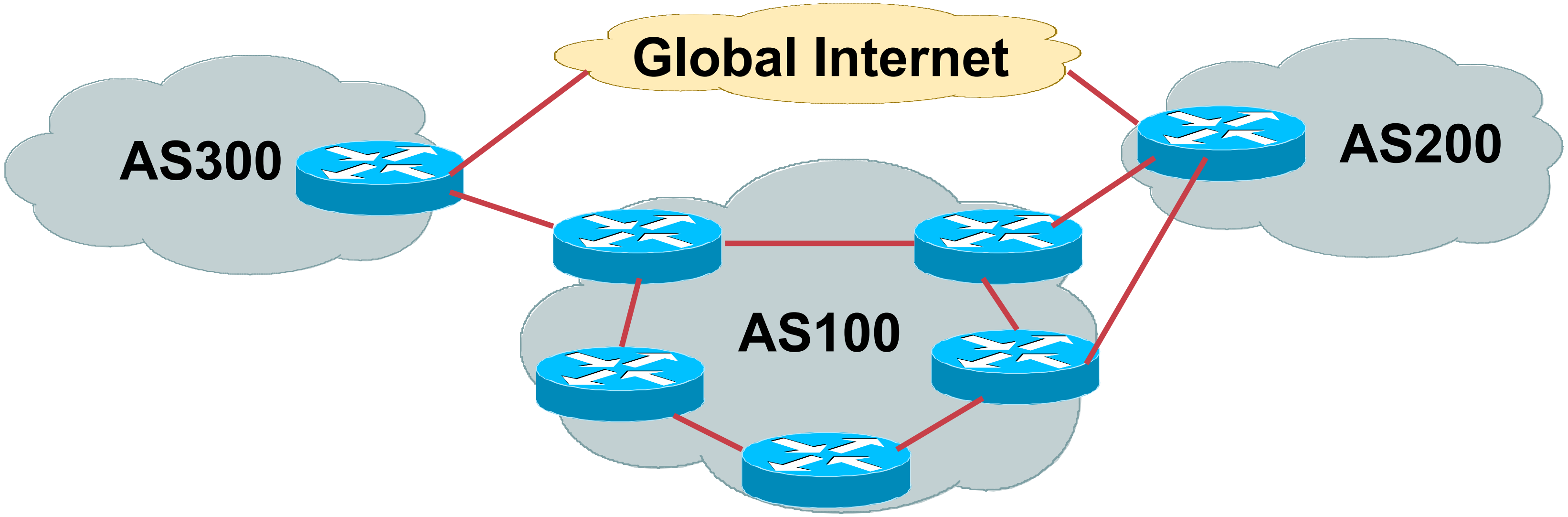
- No need for BGP
- Point static default to upstream ISP
- Upstream ISP advertises stub network
- Policy confined within upstream ISP's policy

Multi-homed Stub Network



- **Use BGP (not IGP or static) to loadshare**
- **Use private AS (ASN > 64511)**
- **Upstream ISP advertises stub network**
- **Policy confined within upstream ISP's policy**

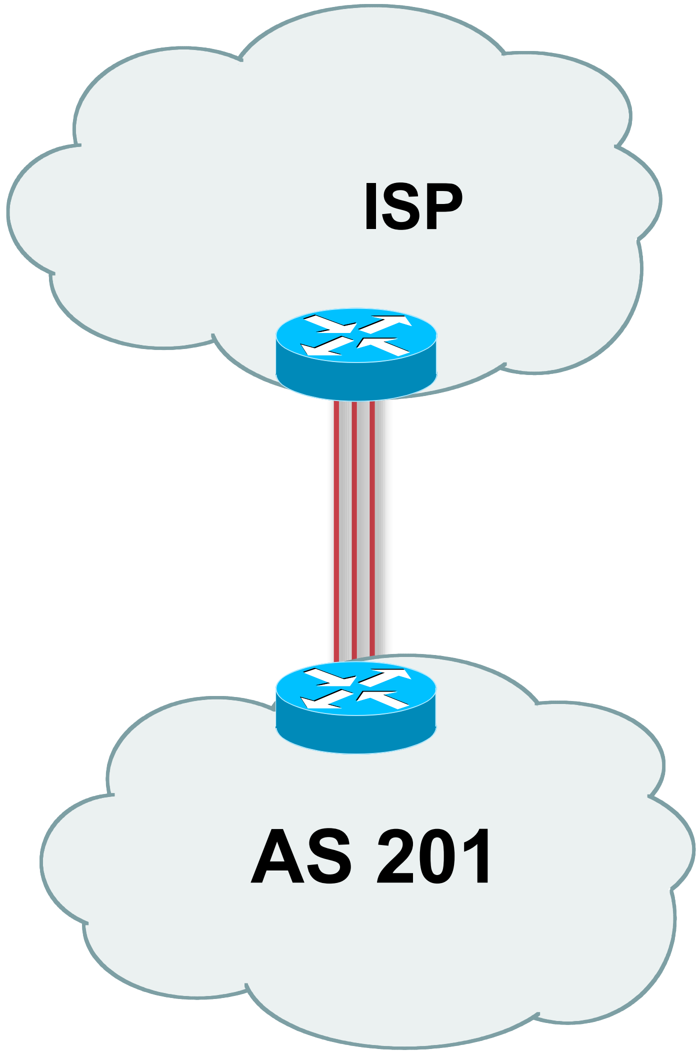
Multi-Homed Network



- **Many situations possible**
  - multiple sessions to same ISP
  - secondary for backup only
  - load-share between primary and secondary
  - selectively use different ISPs

Multiple Sessions to an ISP

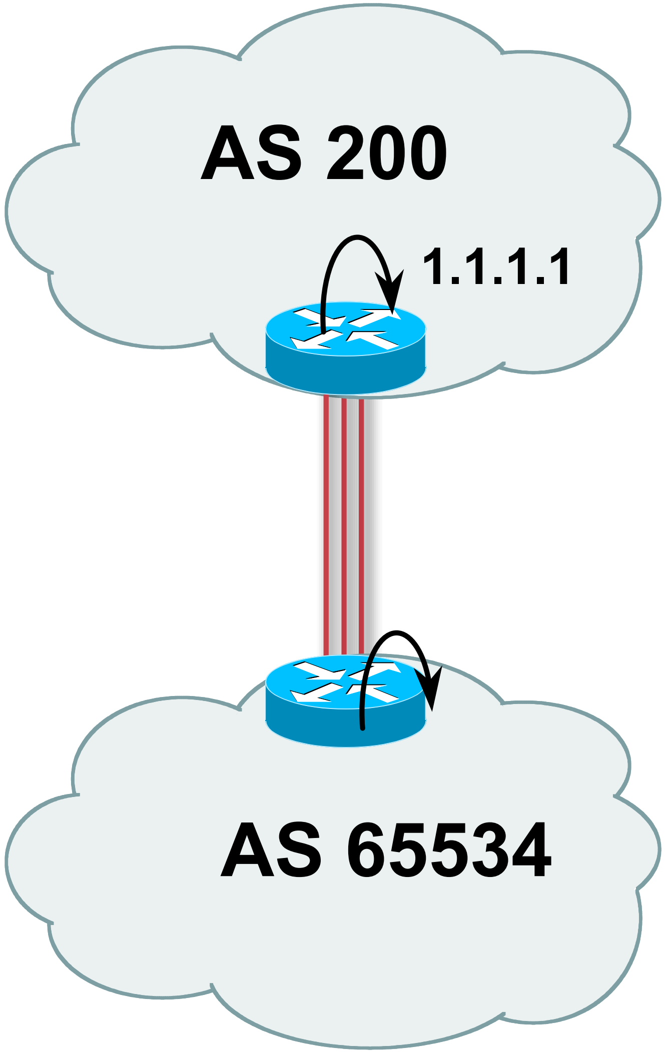
- **Several options**
  - **ebgp multihop**
  - **bgp multipath**
  - **cef loadsharing**
  - **bgp attribute manipulation**



Multiple Sessions to an ISP – Example One

- Use eBGP multihop
  - eBGP to loopback addresses
  - eBGP prefixes learned with loopback address as next hop
- Cisco IOS

```
router bgp 65534
 neighbor 1.1.1.1 remote-as 200
 neighbor 1.1.1.1 ebgp-multihop 2
!
ip route 1.1.1.1 255.255.255.255 serial 1/0
ip route 1.1.1.1 255.255.255.255 serial 1/1
ip route 1.1.1.1 255.255.255.255 serial 1/2
```



Multiple Sessions to an ISP – Example One

- Try and avoid use of ebgp-multihop unless:

  It's absolutely necessary –or–

  Loadsharing across multiple links

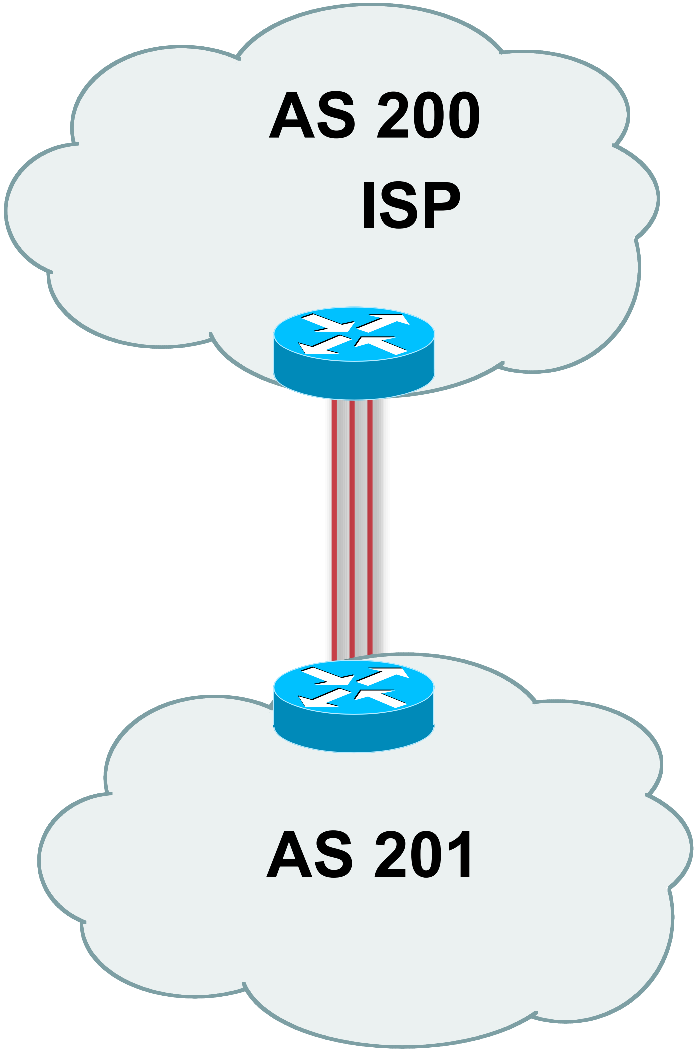
- Many ISPs discourage its use, for example:

> **We will run eBGP multihop, but do not support it as a standard offering because customers generally have a hard time managing it due to:**
> **• routing loops**
> **• failure to realise that BGP session stability problems are usually due connectivity problems between their CPE and their BGP speaker**

Multiple Sessions to an ISP
bgp multi path

- Three BGP sessions required
- limit of 6 parallel paths

```
router bgp 201
 neighbor 1.1.2.1 remote-as 200
 neighbor 1.1.2.5 remote-as 200
 neighbor 1.1.2.9 remote-as 200
 maximum-paths 3
```



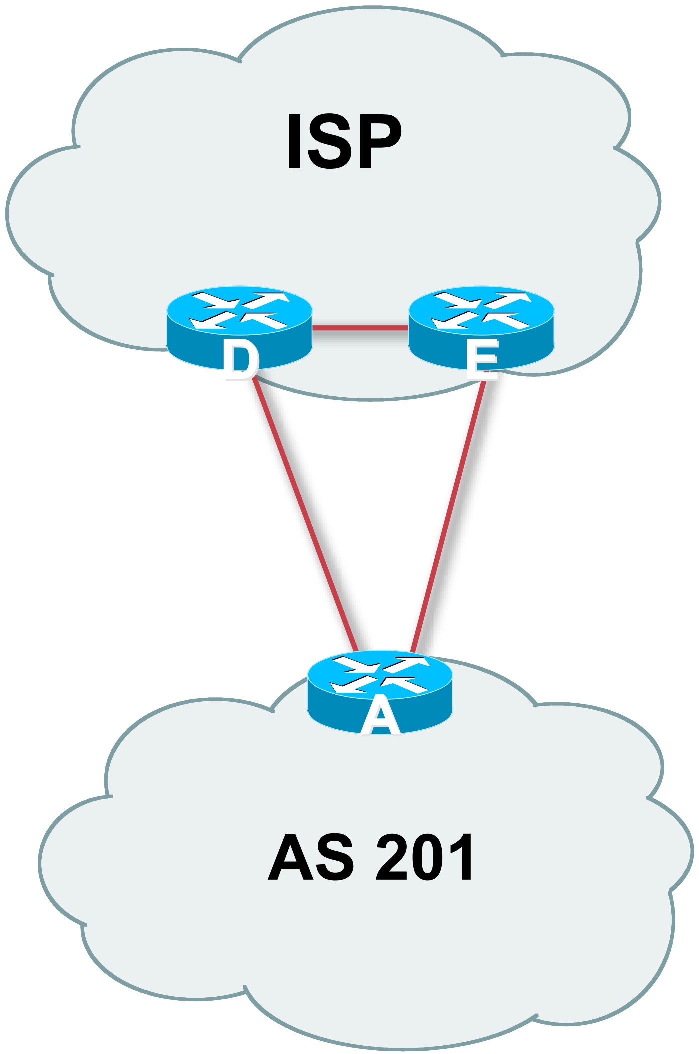
Multiple Sessions to an ISP

- **Use eBGP multi-path to install multiple paths in IP table**

```
router bgp 201
 maximum-path <1-6>
```

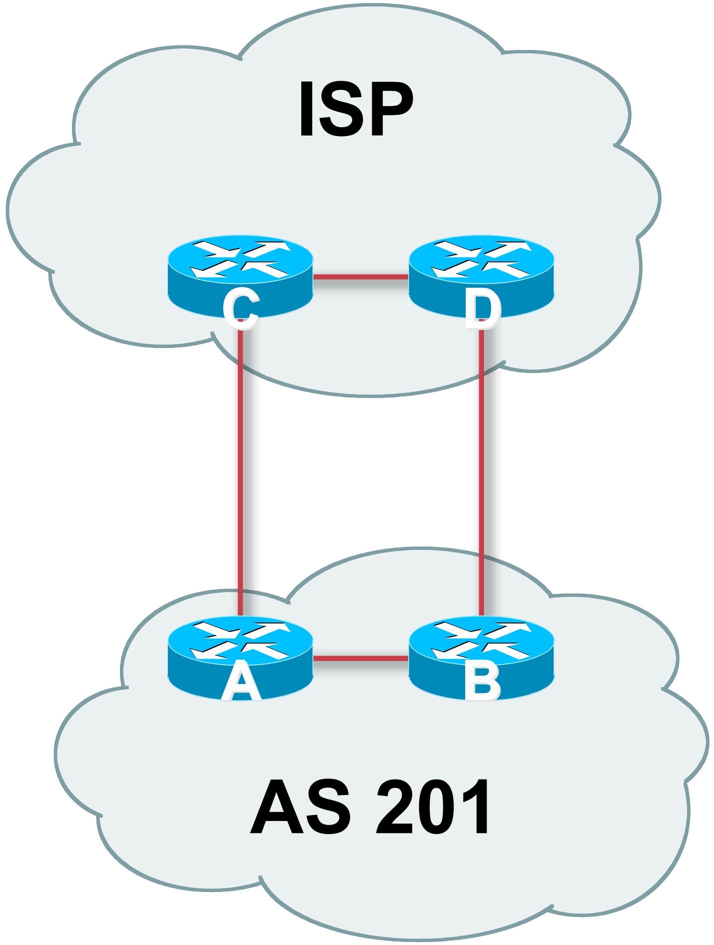
- **Load share over the alternate paths**

  per destination loadsharing



Multiple Sessions to an ISP

- Simplest scheme is to use defaults
- Learn/advertise prefixes for better control
- Planning and some work required to achieve loadsharing
  - Point default towards one ISP
  - Learn selected prefixes from second ISP
  - Modify the number of prefixes learnt to achieve acceptable load sharing
- No magic solution



Preparing the network

Before we begin…

Preparing the Network

- We will deploy BGP across the network before we try and multihome
- BGP will be used therefore an ASN is required
- If multihoming to different ISPs, public ASN needed:

    Either go to upstream ISP who is a registry member, or

    Apply to the RIR yourself for a one off assignment, or

    Ask an ISP who is a registry member, or

    Join the RIR and get your own IP address allocation too (this option strongly recommended)!

Preparing the Network
Initial Assumptions

- **The network is not running any BGP at the moment**

  single statically routed connection to upstream ISP

- **The network is not running any IGP at all**

  Static default and routes through the network to do “routing”

Preparing the Network
First Step: IGP

- Decide on IGP: OSPF or ISIS ☺
- Assign loopback interfaces and /32 addresses to each router which will run the IGP
    - Loopback is OSPF and BGP router id
    - Used for iBGP and route origination
- Deploy IGP (e.g. OSPF)
    - IGP can be deployed with NO IMPACT on the existing static routing
        - OSPF distance is 110, static distance is 1
        - Smallest distance wins

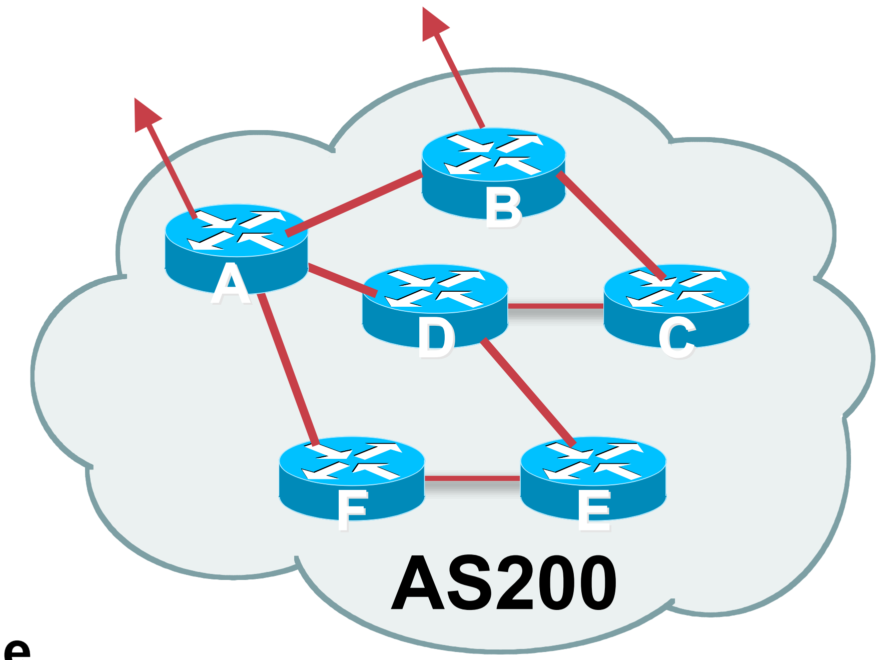
Preparing the Network
Second Step: iBGP

- **Second step is to configure the local network to use iBGP**
- **iBGP can run on**

  all routers, or

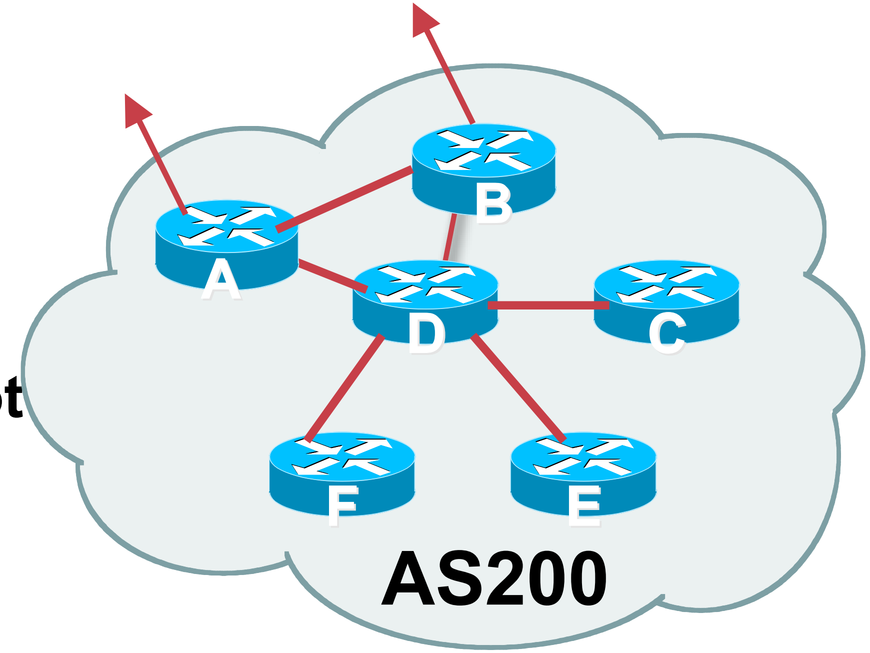
  a subset of routers, or

  just on the upstream edge
- ***iBGP must run on all routers which are in the transit path between external connections***



Preparing the Network
Second Step: iBGP (Transit Path)

- ***iBGP must run on all routers which are in the transit path between external connections***
- **Routers C, E and F are not in the transit path**
  - **Static routes or IGP will suffice**
- **Router D is in the transit path**
  - **Will need to be in iBGP mesh, otherwise routing loops will result**



Preparing the Network Layers

- Typical SP networks have three layers:
  - Core – the backbone, usually the transit path
  - Distribution – the middle, PoP aggregation layer
  - Aggregation – the edge, the devices connecting customers

Preparing the Network Aggregation Layer

- iBGP is optional
  - Many ISPs run iBGP here, either partial routing (more common) or full routing (less common)
  - Full routing is not needed unless customers want full table
  - Partial routing is cheaper/easier, might usually consist of internal prefixes and, optionally, external prefixes to aid external load balancing
    - Communities and peer-groups make this administratively easy
- Many aggregation devices can't run iBGP
  - Static routes from distribution devices for address pools
  - IGP for best exit

Preparing the Network
Distribution Layer

- **Usually runs iBGP**
  - **Partial or full routing (as with aggregation layer)**
- **But does not have to run iBGP**
  - **IGP is then used to carry customer prefixes (does not scale)**
  - **IGP is used to determine nearest exit**
- **Networks which plan to grow large should deploy iBGP from day one**
  - **Migration at a later date is extra work**
  - **No extra overhead in deploying iBGP, indeed IGP benefits**

Preparing the Network
Core Layer

- Core of network is usually the transit path
- iBGP necessary between core devices
  - Full routes or partial routes:
    - Transit ISPs carry full routes in core
    - Edge ISPs carry partial routes only
- Core layer includes AS border routers

Preparing the Network
iBGP Implementation

- **Decide on:**
  - **Best iBGP policy (full vs partial route mix)**
  - **iBGP scaling technique (communities, route-reflectors, peer-groups)**
- **Then deploy iBGP:**
  - **Step 1: Introduce iBGP (making sure that iBGP distance is greater than IGP distance)**
  - **Step 2: Install customer prefixes into iBGP**
  - **Step 3: Make iBGP distance less than IGP**
    - **Check! Does the network still work?**
  - **Step 4: Withdraw customer prefixes from the IGP**
  - **Step 5: Deployment of eBGP follows**

Preparing the Network Configuration – Before BGP

```
interface loopback 0
 ip address 121.10.255.1 255.255.255.255
!
interface serial 0/0
 ip address 121.10.0.1 255.255.255.252
!
interface serial 0/1
 ip address 121.10.0.5 255.255.255.252
!
router ospf 100
 network 121.10.255.1 0.0.0.0 area 0
 passive-interface loopback 0
 redistribute connected subnets     ! Point-to-point links
 redistribute static subnets        ! Customer networks
!
ip route 121.10.24.0 255.255.252.0 serial 0/0
ip route 121.10.28.0 255.255.254.0 serial 0/1
```

Add loopback configuration if not already there

Preparing the Network Configuration – Steps 1 & 2

```
! interface and OSPF configuration unchanged
!
router bgp 100
 redistribute connected subnets route-map point-to-point
 neighbor 121.10.1.2 remote-as 100
 neighbor 121.10.1.2 next-hop-self
 ...
 network 121.10.24.0 mask 255.255.252.0
 network 121.10.28.0 mask 255.255.254.0
 distance bgp 200 200 200
!
ip route 121.10.24.0 255.255.252.0 serial 0/0
ip route 121.10.28.0 255.255.254.0 serial 0/1
!
route-map point-to-point permit 5
 match ip address 1
 set community 100:1
!
access-list 1 permit 121.10.0.0 0.0.255.255
```

Add BGP and related configuration in red

Preparing the Network Configuration – Steps 3 & 4

```
! interface configuration unchanged
!
router ospf 100
 network 121.10.255.1 0.0.0.0 area 0
 passive-interface loopback 0
!
router bgp 100
 redistribute connected route-map point-to-point
 neighbor 121.10.1.2 remote-as 100
 neighbor 121.10.1.2 next-hop-self
 ...
 network 121.10.24.0 mask 255.255.252.0
 network 121.10.28.0 mask 255.255.254.0
 distance bgp 20 20 20       ! reduced BGP distance
!
ip route 121.10.24.0 255.255.252.0 serial 0/0
ip route 121.10.28.0 255.255.254.0 serial 0/1
!
...etc...
```

OSPF redistribution has been removed

Preparing the Network Configuration – Step 5

```
! interface configuration unchanged
!
router ospf 100
 network 121.10.255.1 0.0.0.0 area 0
 passive-interface loopback 0
!
router bgp 100
 redistribute connected route-map point-to-point
 neighbor 121.10.1.2 remote-as 100
 neighbor 121.10.1.2 next-hop-self
 ...
 network 121.10.24.0 mask 255.255.252.0
 network 121.10.28.0 mask 255.255.254.0
 distance bgp 200 200 200    ! BGP distance restored
!
ip route 121.10.24.0 255.255.252.0 serial 0/0
ip route 121.10.28.0 255.255.254.0 serial 0/1
!
...etc...
```

Preparing the Network Configuration Summary

- Customer networks are now in iBGP
  - iBGP deployed over the backbone
  - Full or Partial or Upstream Edge only
- BGP distance is greater than any IGP
- Now ready to deploy eBGP

Basic Multihoming

Let’s learn to walk before we try running…

Basic Multihoming

- No frills multihoming
- Will look at two cases:
  - Multihoming with the same ISP
  - Multihoming to different ISPs
- Will keep the examples easy
  - Understanding easy concepts will make the more complex scenarios easier to comprehend

Basic Multihoming

- This type is most commonplace at the edge of the Internet
    - Networks here are usually concerned with inbound traffic flows
    - Outbound traffic flows being “nearest exit” is usually sufficient
- Can apply to the leaf ISP as well as Enterprise networks

Two links to the same ISP

Basic – No Redundancy

Two links to the same ISP

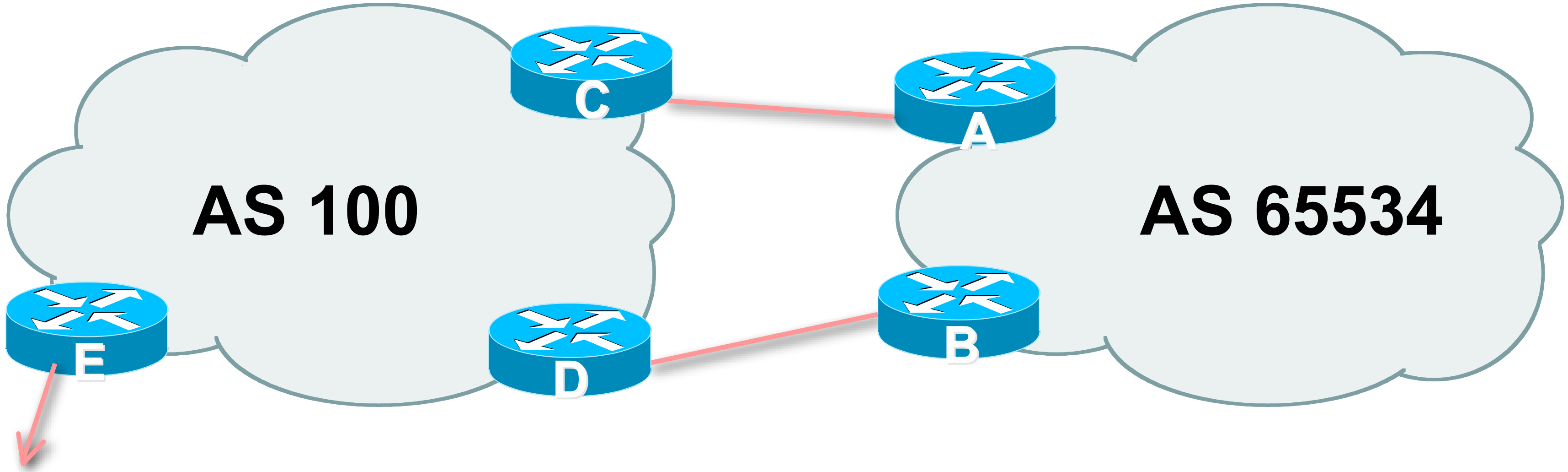
- **Can use BGP for this to aid loadsharing**

  use a private AS (ASN > 64511)

- **upstream ISP proxy aggregates**

  in other words, announces only your address block to the Internet (as would be done if you had one statically routed connection)

Two links to the same ISP



- **AS100 proxy aggregates for AS 65534**

Two links to the same ISP

- **Split /19 and announce as two /20s, one on each link**

  basic inbound loadsharing

- **Example has no practical use, but demonstrates the principles**

Two links to the same ISP

- **Router A Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.240.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 122.102.10.2 remote-as 100
 neighbor 122.102.10.2 prefix-list routerC out
 neighbor 122.102.10.2 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.0.0/20
!
ip route 121.10.0.0 255.255.240.0 null0
ip route 121.10.16.0 255.255.240.0 null0
```

Two links to the same ISP

- **Router B Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.240.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 122.102.10.6 remote-as 100
 neighbor 122.102.10.6 prefix-list routerD out
 neighbor 122.102.10.6 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 121.10.16.0/20
!
ip route 121.10.0.0 255.255.240.0 null0
ip route 121.10.16.0 255.255.240.0 null0
```

Two links to the same ISP

- **Router C Configuration**

```
router bgp 100
 neighbor 122.102.10.1 remote-as 65534
 neighbor 122.102.10.1 default-originate
 neighbor 122.102.10.1 prefix-list Customer in
 neighbor 122.102.10.1 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/20
ip prefix-list default permit 0.0.0.0/0
```

Two links to the same ISP

- **Router D Configuration**

```
router bgp 100
 neighbor 122.102.10.5 remote-as 65534
 neighbor 122.102.10.5 default-originate
 neighbor 122.102.10.5 prefix-list Customer in
 neighbor 122.102.10.5 prefix-list default out
!
ip prefix-list Customer permit 121.10.16.0/20
ip prefix-list default permit 0.0.0.0/0
```

Two links to the same ISP

- **Router E is AS100 border router**

    removes prefixes in the private AS from external announcements

    implements the proxy aggregation for the customer prefixes

Two links to the same ISP

- **Router E Configuration**

```
router bgp 100
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 filter-list 1 out
!
ip route 121.10.0.0 255.255.224.0 null0
!
ip as-path access-list 1 deny ^65534$
ip as-path access-list 1 permit ^$
```

- **Private AS still visible inside AS100**

Two links to the same ISP

- **Big Problem:**

  no backup in case of link failure

- **/19 address block not announced**
- **AS Path filtering "awkward"**

  easier to use bgp command

  ```
  neighbor x.x.x.x remove-private-AS
  ```

Two links to the same ISP

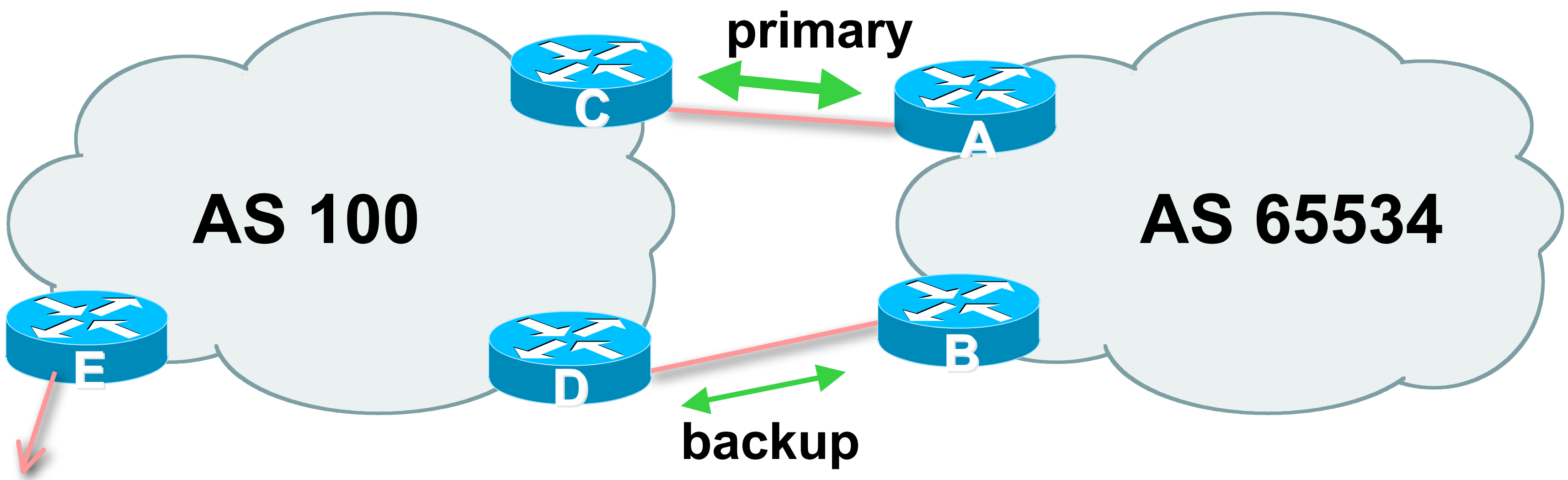
One link primary, the other link backup only

Two links to the same ISP (one as backup only)

- **Applies when end-site has bought a large primary WAN link to their upstream a small secondary WAN link as the backup**

  For example, primary path might be an E1, backup might be 64kbps

Two links to the same ISP (one as backup only)



- **AS100 removes private AS and any customer subprefixes from Internet announcement**

Two links to the same ISP (one as backup only)

- **Announce /19 aggregate on each link**

  primary link:

  Outbound – announce /19 unaltered

  Inbound – receive default route

  backup link:

  Outbound – announce /19 with increased metric

  Inbound – received default, and reduce local preference

- **When one link fails, the announcement of the /19 aggregate via the other link ensures continued connectivity**

Two links to the same ISP (one as backup only)

- **Router A Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.2 remote-as 100
 neighbor 122.102.10.2 description RouterC
 neighbor 122.102.10.2 prefix-list aggregate out
 neighbor 122.102.10.2 prefix-list default in
!
ip prefix-list aggregate permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
```

Two links to the same ISP (one as backup only)

- **Router B Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.6 remote-as 100
 neighbor 122.102.10.6 description RouterD
 neighbor 122.102.10.6 prefix-list aggregate out
 neighbor 122.102.10.6 route-map routerD-out out
 neighbor 122.102.10.6 prefix-list default in
 neighbor 122.102.10.6 route-map routerD-in in
!
..next slide
```

Two links to the same ISP (one as backup only)

```
ip prefix-list aggregate permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
route-map routerD-out permit 10
 match ip address prefix-list aggregate
 set metric 10
route-map routerD-out permit 20
!
route-map routerD-in permit 10
 set local-preference 90
!
```

Two links to the same ISP (one as backup only)

- **Router C Configuration (main link)**

```
router bgp 100
 neighbor 122.102.10.1 remote-as 65534
 neighbor 122.102.10.1 default-originate
 neighbor 122.102.10.1 prefix-list Customer in
 neighbor 122.102.10.1 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
```

Two links to the same ISP (one as backup only)

- **Router D Configuration (backup link)**

```
router bgp 100
 neighbor 122.102.10.5 remote-as 65534
 neighbor 122.102.10.5 default-originate
 neighbor 122.102.10.5 prefix-list Customer in
 neighbor 122.102.10.5 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
```

Two links to the same ISP (one as backup only)

- **Router E Configuration**

```
router bgp 100
 neighbor 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 remove-private-AS
 neighbor 122.102.10.17 prefix-list Customer out
!
ip prefix-list Customer permit 121.10.0.0/19
```

- **Router E removes the private AS and customer's subprefixes from external announcements**
- **Private AS still visible inside AS100**

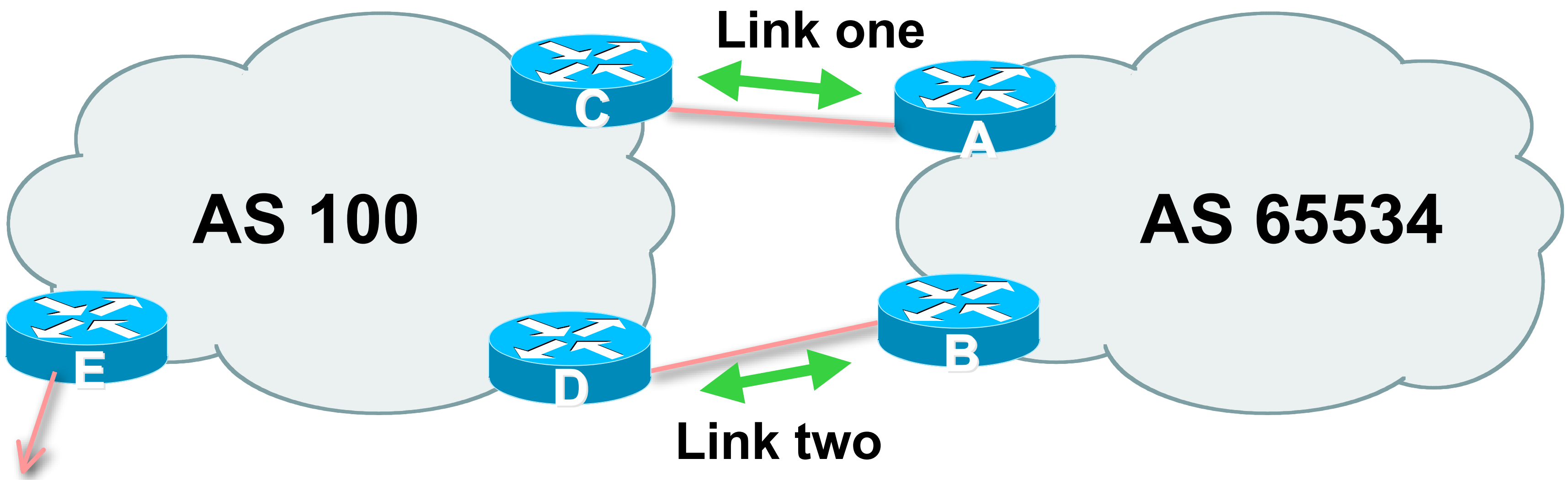
Two links to the same ISP

With Redundancy and Loadsharing

Loadsharing to the same ISP

- More common case
- End sites tend not to buy circuits and leave them idle, only used for backup as in previous example
- This example assumes equal capacity circuits
  - Unequal capacity circuits requires more refinement – see later

Loadsharing to the same ISP



- **Border router E in AS100 removes private AS and any customer subprefixes from Internet announcement**

Loadsharing to the same ISP (with redundancy)

- **Announce /19 aggregate on each link**
- **Split /19 and announce as two /20s, one on each link**

  basic inbound loadsharing

  assumes equal circuit capacity and even spread of traffic across address block
- **Vary the split until "perfect" loadsharing achieved**
- **Accept the default from upstream**

  basic outbound loadsharing by nearest exit

  okay in first approx as most ISP and end-site traffic is inbound

Loadsharing to the same ISP (with redundancy)

- **Router A Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.0.0 mask 255.255.240.0
 neighbor 122.102.10.2 remote-as 100
 neighbor 122.102.10.2 prefix-list routerC out
 neighbor 122.102.10.2 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.0.0/20
ip prefix-list routerC permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.240.0 null0
ip route 121.10.0.0 255.255.224.0 null0
```

Loadsharing to the same ISP (with redundancy)

- **Router B Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 122.102.10.6 remote-as 100
 neighbor 122.102.10.6 prefix-list routerD out
 neighbor 122.102.10.6 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.16.0/20
ip prefix-list routerC permit 121.10.0.0/19
!
ip route 121.10.16.0 255.255.240.0 null0
ip route 121.10.0.0 255.255.224.0 null0
```

Loadsharing to the same ISP (with redundancy)

- **Router C Configuration**

```
router bgp 100
 neighbor 122.102.10.1 remote-as 65534
 neighbor 122.102.10.1 default-originate
 neighbor 122.102.10.1 prefix-list Customer in
 neighbor 122.102.10.1 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/19 le 20
ip prefix-list default permit 0.0.0.0/0
```

- **Router C only allows in /19 and /20 prefixes from customer block**
- **Router D configuration is identical**

Loadsharing to the same ISP (with redundancy)

- **Default route for outbound traffic?**

  Use default-information originate for the IGP and rely on IGP metrics for nearest exit

  e.g. on router A:

```
router ospf 65534
 default-information originate metric 2 metric-type 1
```

Loadsharing to the same ISP (with redundancy)

- **Router C Configuration**

```
router bgp 100
 neighbor 122.102.10.1 remote-as 65534
 neighbor 122.102.10.1 default-originate
 neighbor 122.102.10.1 prefix-list Customer in
 neighbor 122.102.10.1 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/19 le 20
ip prefix-list default permit 0.0.0.0/0
```

- **Router C only allows in /19 and /20 prefixes from customer block**

Loadsharing to the same ISP (with redundancy)

- **Router D Configuration**

```
router bgp 100
 neighbor 122.102.10.5 remote-as 65534
 neighbor 122.102.10.5 default-originate
 neighbor 122.102.10.5 prefix-list Customer in
 neighbor 122.102.10.5 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/19 le 20
ip prefix-list default permit 0.0.0.0/0
```

- **Router D only allows in /19 and /20 prefixes from customer block**

Loadsharing to the same ISP (with redundancy)

- **Router E is AS100 border router**

  removes subprefixes in the private AS from external announcements

  removes the private AS from external announcement of the customer /19

Loadsharing to the same ISP (with redundancy)

- **Router E Configuration**

```
router bgp 100
 neighbor 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 remove-private-AS
 neighbor 122.102.10.17 prefix-list Customer out
!
ip prefix-list Customer permit 121.10.0.0/19
```

- **Private AS still visible inside AS100**

Loadsharing to the same ISP (with redundancy)

- Loadsharing configuration is only on customer router
- Upstream ISP has to

  remove customer subprefixes from external announcements

  remove private AS from external announcements
- Could also use BGP communities

Two links to the same ISP

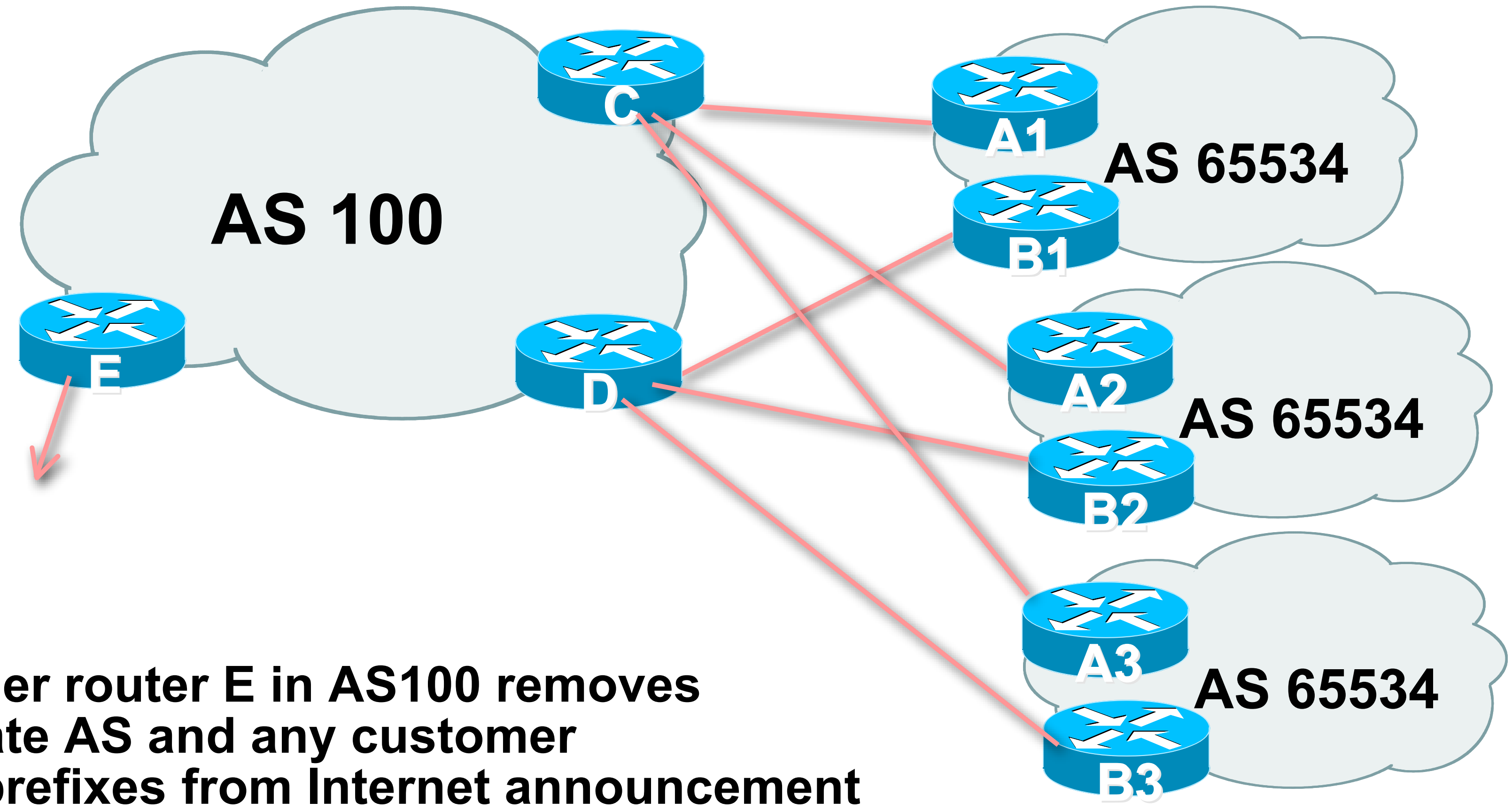
Multiple Dualhomed Customers

(RFC2270)

Multiple Dualhomed Customers (RFC2270)

- **Unusual for an ISP just to have one dualhomed customer**
  - **Valid/valuable service offering for an ISP with multiple PoPs**
  - **Better for ISP than having customer multihome with another provider!**
- **Look at scaling the configuration**
  - **⇒ Simplifying the configuration**
  - **Using templates, peer-groups, etc**
  - **Every customer has the same configuration (basically)**

Multiple Dualhomed Customers (RFC2270)



- **Border router E in AS100 removes private AS and any customer subprefixes from Internet announcement**

Multiple Dualhomed Customers (RFC2270)

- **Customer announcements as per previous example**
- **Use the *same* private AS for each customer**
  - documented in RFC2270
  - address space is not overlapping
  - each customer hears default only
- **Router A*n* and B*n* configuration same as Router A and B previously**

Multiple Dualhomed Customers (RFC2270)

- **Router A1 Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.0.0 mask 255.255.240.0
 neighbor 122.102.10.2 remote-as 100
 neighbor 122.102.10.2 prefix-list routerC out
 neighbor 122.102.10.2 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.0.0/20
ip prefix-list routerC permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.240.0 null0
ip route 121.10.0.0 255.255.224.0 null0
```

Multiple Dualhomed Customers (RFC2270)

- **Router B1 Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 122.102.10.6 remote-as 100
 neighbor 122.102.10.6 prefix-list routerD out
 neighbor 122.102.10.6 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 121.10.16.0/20
ip prefix-list routerD permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.224.0 null0
ip route 121.10.16.0 255.255.240.0 null0
```

Multiple Dualhomed Customers (RFC2270)

- **Router C Configuration**

```
router bgp 100
 neighbor bgp-customers peer-group
 neighbor bgp-customers remote-as 65534
 neighbor bgp-customers default-originate
 neighbor bgp-customers prefix-list default out
 neighbor 122.102.10.1 peer-group bgp-customers
 neighbor 122.102.10.1 description Customer One
 neighbor 122.102.10.1 prefix-list Customer1 in
 neighbor 122.102.10.9 peer-group bgp-customers
 neighbor 122.102.10.9 description Customer Two
 neighbor 122.102.10.9 prefix-list Customer2 in
```

Multiple Dualhomed Customers (RFC2270)

```
 neighbor 122.102.10.17 peer-group bgp-customers
 neighbor 122.102.10.17 description Customer Three
 neighbor 122.102.10.17 prefix-list Customer3 in
!
ip prefix-list Customer1 permit 121.10.0.0/19 le 20
ip prefix-list Customer2 permit 121.16.64.0/19 le 20
ip prefix-list Customer3 permit 121.14.192.0/19 le 20
ip prefix-list default permit 0.0.0.0/0
```

- Router C only allows in /19 and /20 prefixes from customer block

Multiple Dualhomed Customers (RFC2270)

- **Router D Configuration**

```
router bgp 100
 neighbor bgp-customers peer-group
 neighbor bgp-customers remote-as 65534
 neighbor bgp-customers default-originate
 neighbor bgp-customers prefix-list default out
 neighbor 122.102.10.5 peer-group bgp-customers
 neighbor 122.102.10.5 description Customer One
 neighbor 122.102.10.5 prefix-list Customer1 in
 neighbor 122.102.10.13 peer-group bgp-customers
 neighbor 122.102.10.13 description Customer Two
 neighbor 122.102.10.13 prefix-list Customer2 in
```

Multiple Dualhomed Customers (RFC2270)

```
 neighbor 122.102.10.21 peer-group bgp-customers
 neighbor 122.102.10.21 description Customer Three
 neighbor 122.102.10.21 prefix-list Customer3 in
!
ip prefix-list Customer1 permit 121.10.0.0/19 le 20
ip prefix-list Customer2 permit 121.16.64.0/19 le 20
ip prefix-list Customer3 permit 121.14.192.0/19 le 20
ip prefix-list default permit 0.0.0.0/0
```

- **Router D only allows in /19 and /20 prefixes from customer block**

Multiple Dualhomed Customers (RFC2270)

- **Router E Configuration**

  assumes customer address space is not part of upstream's address block

```
router bgp 100
 neighbor 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 remove-private-AS
 neighbor 122.102.10.17 prefix-list Customers out
!
ip prefix-list Customers permit 121.10.0.0/19
ip prefix-list Customers permit 121.16.64.0/19
ip prefix-list Customers permit 121.14.192.0/19
```

- **Private AS still visible inside AS100**

Multiple Dualhomed Customers (RFC2270)

- **If customers' prefixes come from ISP's address block**

  do NOT announce them to the Internet

  announce ISP aggregate only

- **Router E configuration:**

```
router bgp 100
 neighbor 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 prefix-list my-aggregate out
!
ip prefix-list my-aggregate permit 121.8.0.0/13
```

Multihoming Summary

- Use private AS for multihoming to upstream
- Leak subprefixes to upstream only to aid loadsharing
- Upstream Router E configuration is uniform across all scenarios

Basic Multihoming

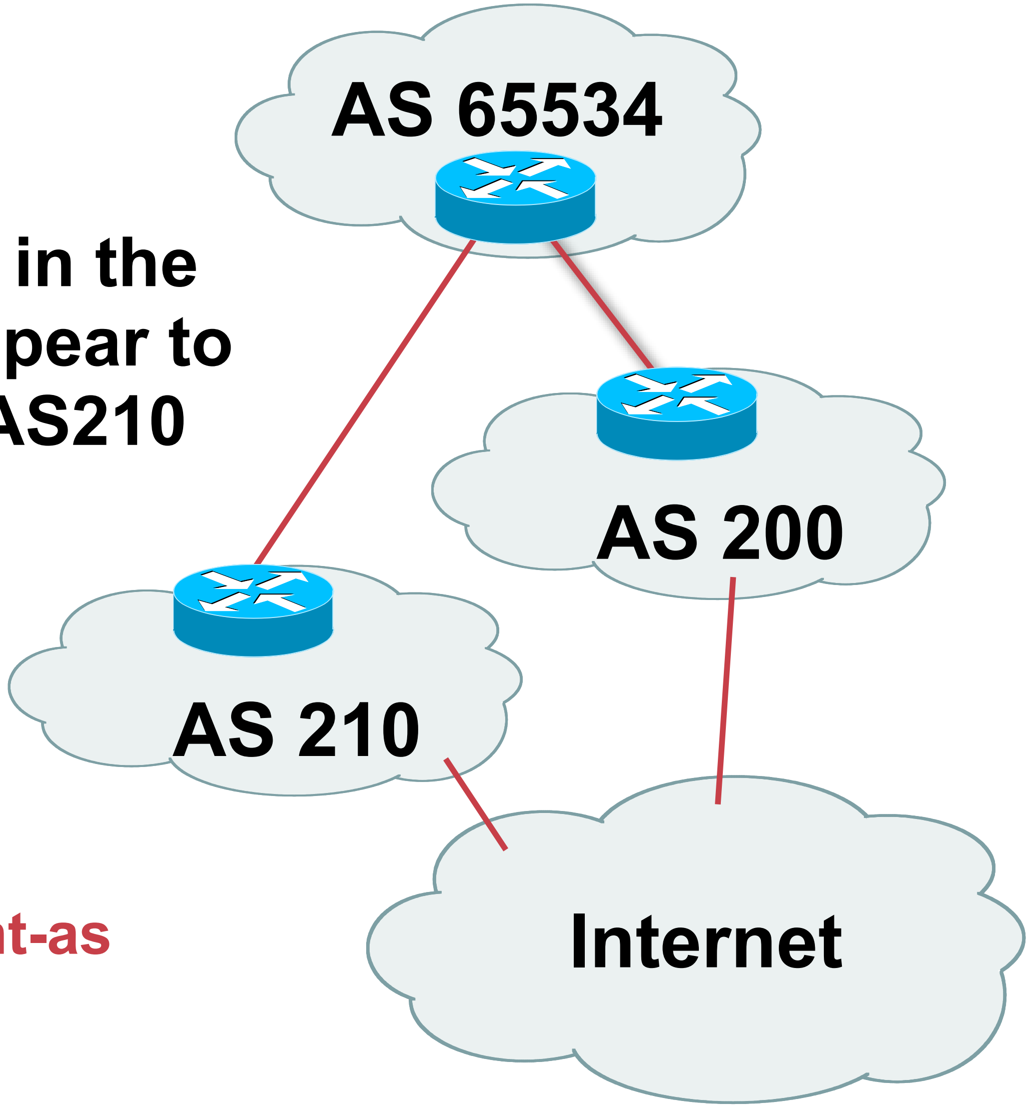
Multihoming to Different ISPs

Two links to different ISPs

- Use a Public AS
  - Or use private AS if agreed with the other ISP
  - But some people don't like the "inconsistent-AS" which results from use of a private-AS
- Address space comes from
  - both upstreams or
  - Regional Internet Registry
- Configuration concepts very similar

Inconsistent-AS?

- Viewing the prefixes originated by AS65534 in the Internet shows they appear to be originated by both AS210 and AS200
  - This is NOT bad
  - Nor is it illegal
- IOS command is
  - show ip bgp inconsistent-as



Two links to different ISPs

Basic – No Redundancy

Two links to different ISPs (no redundancy)

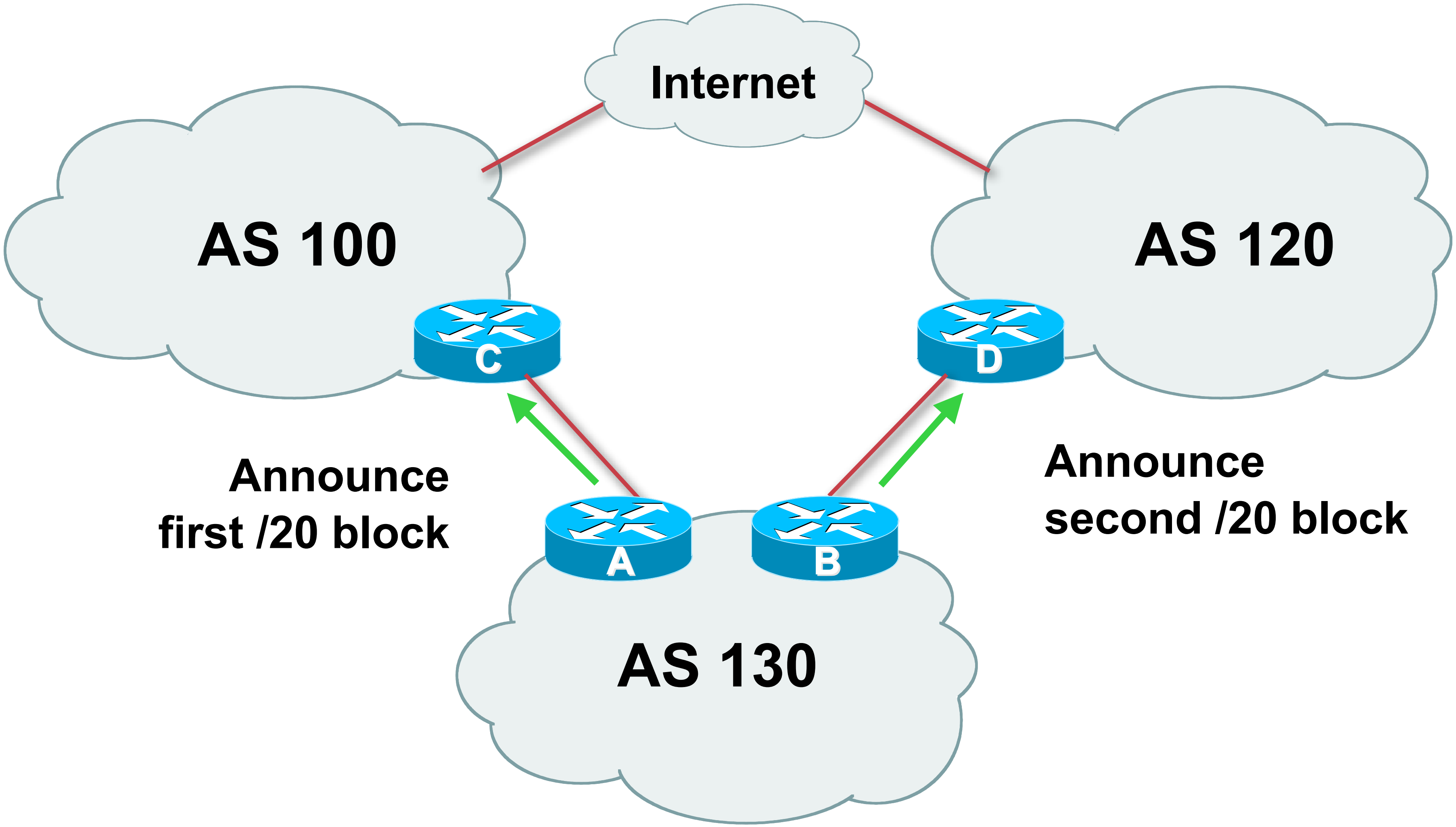
- **Example for PI space**

  ISP network, or large enterprise site

- **Split /19 and announce as two /20s, one on each link**

  basic inbound loadsharing

Two links to different ISPs (no redundancy)



Two links to different ISPs (no redundancy)

- **Router A Configuration**

```
router bgp 130
 network 121.10.0.0 mask 255.255.240.0
 neighbor 122.102.10.1 remote-as 100
 neighbor 122.102.10.1 prefix-list routerC out
 neighbor 122.102.10.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.0.0/20
```

Two links to different ISPs (no redundancy)

- **Router B Configuration**

```
router bgp 130
 network 121.10.16.0 mask 255.255.240.0
 neighbor 120.1.5.1 remote-as 120
 neighbor 120.1.5.1 prefix-list routerD out
 neighbor 120.1.5.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 121.10.16.0/20
```

Two links to different ISPs (no redundancy)

- **Router C Configuration**

```
router bgp 100
 neighbor 121.10.1.1 remote-as 130
 neighbor 121.10.1.1 default-originate
 neighbor 121.10.1.1 prefix-list AS130cust in
 neighbor 121.10.1.1 prefix-list default-out out
!
```

- **Router C only announces default to AS 130**
- **Router C only accepts AS130’s prefix block**

Two links to different ISPs (no redundancy)

- **Router D Configuration**

```
router bgp 120
 neighbor 120.1.5.1 remote-as 130
 neighbor 120.1.5.1 default-originate
 neighbor 120.1.5.1 prefix-list AS130cust in
 neighbor 120.1.5.1 prefix-list default-out out
!
```

- **Router D only announces default to AS 130**
- **Router D only accepts AS130’s prefix block**

Two links to different ISPs (no redundancy)

- **Big Problem**:

  no backup in case of link failure

- **/19 address block not announced**

Two links to different ISPs

One link primary, the other link backup only

Two links to different ISPs (one as backup only)

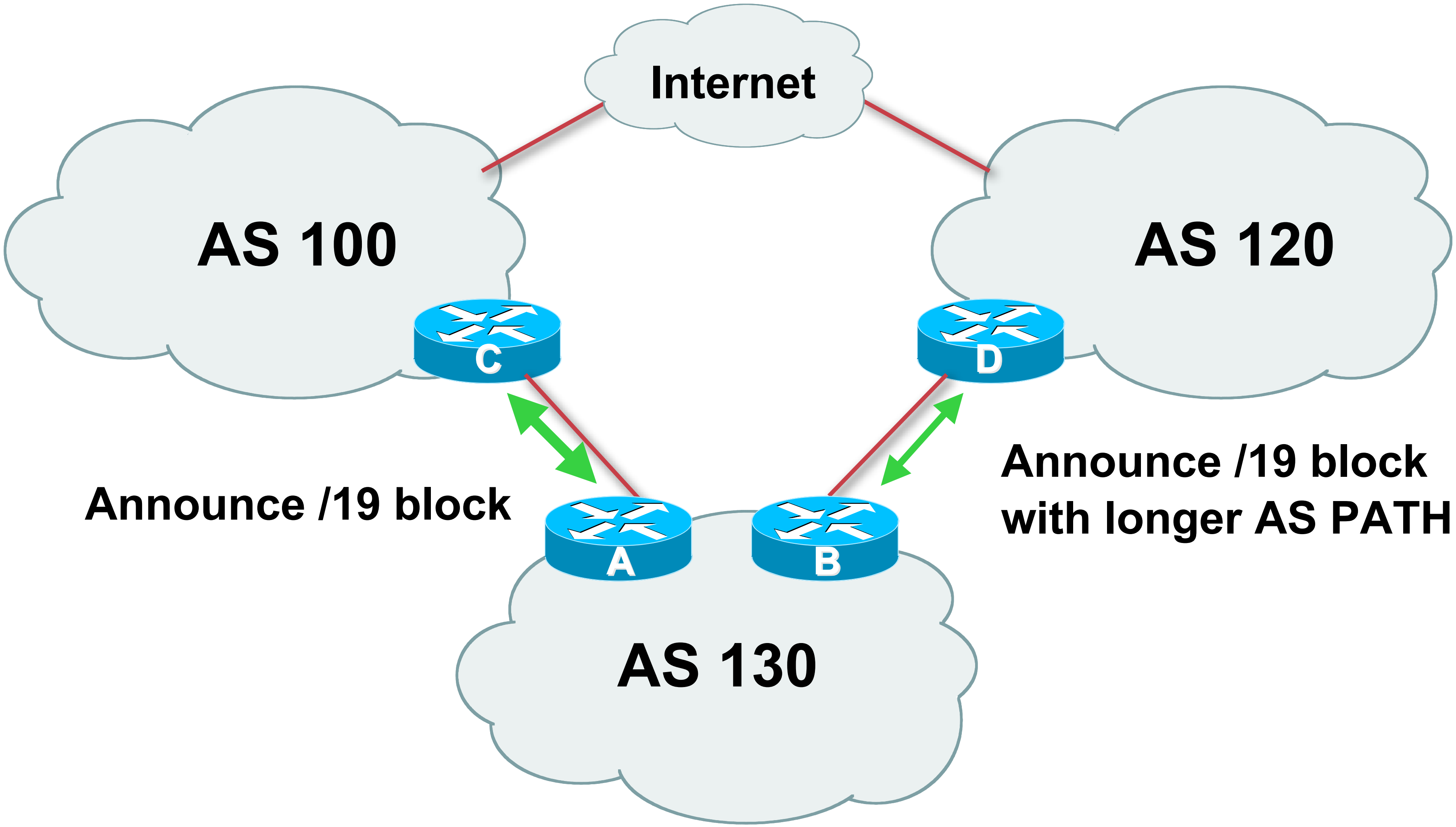
- **Announce /19 aggregate on each link**

  primary link makes standard announcement

  backup link lengthens the AS PATH by using AS PATH prepend

- **When one link fails, the announcement of the /19 aggregate via the other link ensures continued connectivity**

Two links to different ISPs (one as backup only)



Two links to different ISPs (one as backup only)

- **Router A Configuration**

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.1 remote-as 100
 neighbor 122.102.10.1 prefix-list aggregate out
 neighbor 122.102.10.1 prefix-list default in
!
ip prefix-list aggregate permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
```

Two links to different ISPs (one as backup only)

- **Router B Configuration**

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 neighbor 120.1.5.1 remote-as 120
 neighbor 120.1.5.1 prefix-list aggregate out
 neighbor 120.1.5.1 route-map routerD-out out
 neighbor 120.1.5.1 prefix-list default in
 neighbor 120.1.5.1 route-map routerD-in in
!
ip prefix-list aggregate permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
route-map routerD-out permit 10
 set as-path prepend 130 130 130
!
route-map routerD-in permit 10
 set local-preference 80
```

Two links to different ISPs (one as backup only)

- **Not a common situation as most sites tend to prefer using whatever capacity they have**
- **But it shows the basic concepts of using local-prefs and AS-path prepends for engineering traffic in the chosen direction**

Two links to different ISPs

With Redundancy

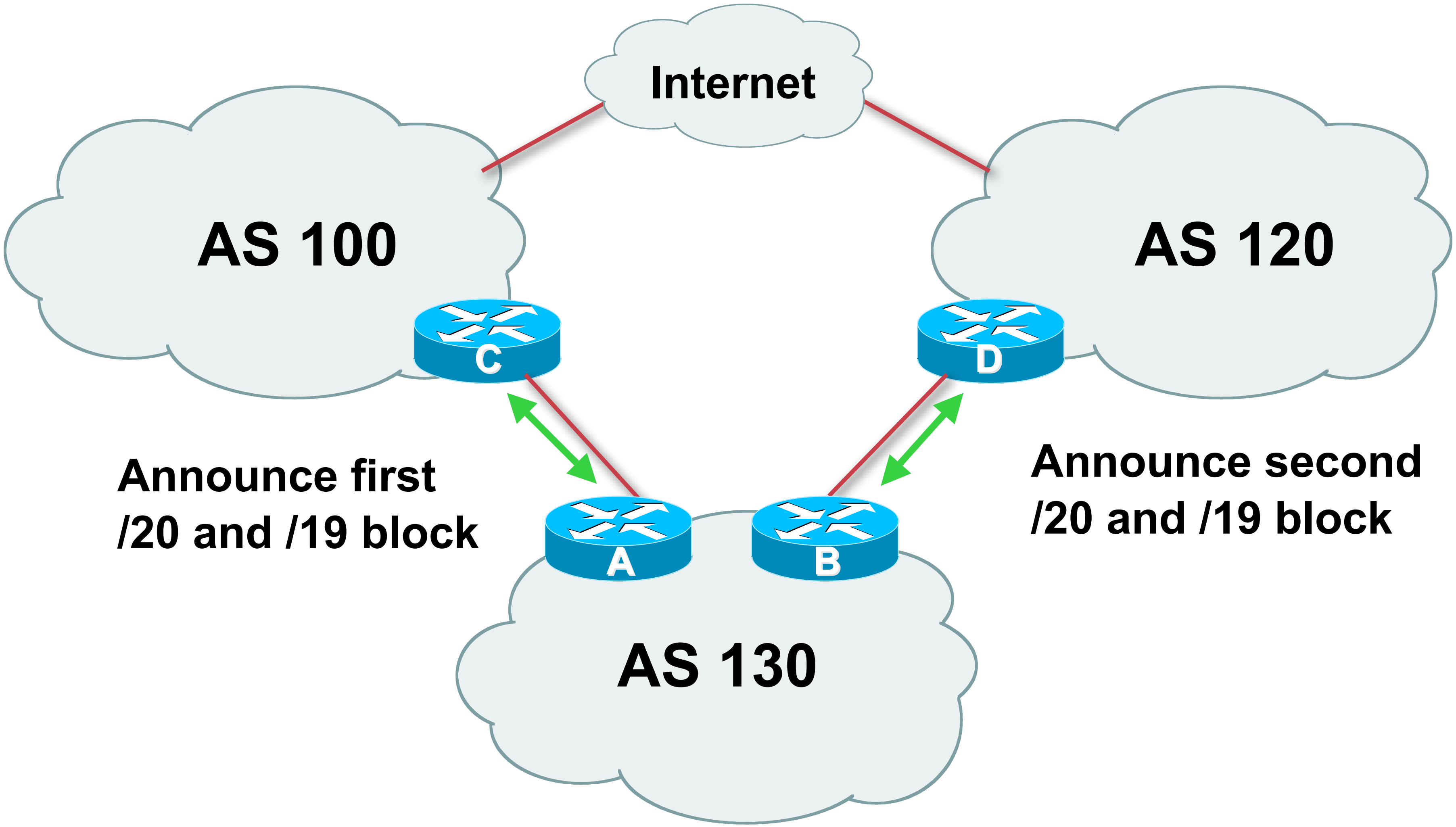
Two links to different ISPs (with redundancy)

- **Announce /19 aggregate on each link**
- **Split /19 and announce as two /20s, one on each link**

  <u>basic</u> inbound loadsharing

- **When one link fails, the announcement of the /19 aggregate via the other ISP ensures continued connectivity**

Two links to different ISPs (with redundancy)



Two links to different ISPs (with redundancy)

- **Router A Configuration**

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.0.0 mask 255.255.240.0
 neighbor 122.102.10.1 remote-as 100
 neighbor 122.102.10.1 prefix-list firstblock out
 neighbor 122.102.10.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
!
ip prefix-list firstblock permit 121.10.0.0/20
ip prefix-list firstblock permit 121.10.0.0/19
```

Two links to different ISPs (with redundancy)

- **Router B Configuration**

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 120.1.5.1 remote-as 120
 neighbor 120.1.5.1 prefix-list secondblock out
 neighbor 120.1.5.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
!
ip prefix-list secondblock permit 121.10.16.0/20
ip prefix-list secondblock permit 121.10.0.0/19
```

Two links to different ISPs (with loadsharing)

- **Loadsharing in this case is very basic**
- **But shows the first steps in designing a load sharing solution**

  Start with a simple concept

  And build on it…!

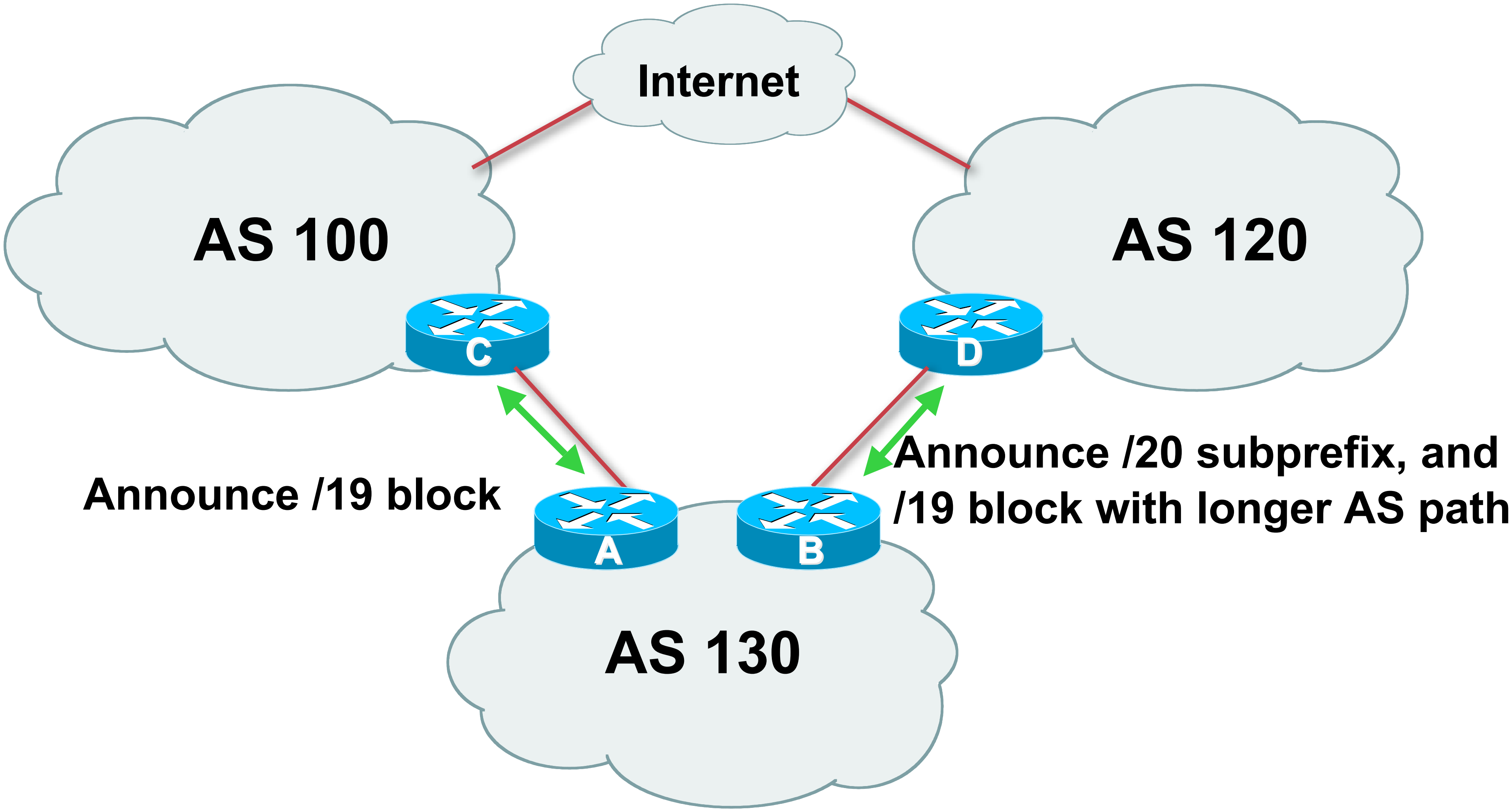
Two links to different ISPs

More Controlled Loadsharing

Loadsharing with different ISPs

- **Announce /19 aggregate on each link**
  - On first link, announce /19 as normal
  - On second link, announce /19 with longer AS PATH, and announce one /20 subprefix
    - controls loadsharing between upstreams and the Internet
- **Vary the subprefix size and AS PATH length until "perfect" loadsharing achieved**
- **Still require redundancy!**

Loadsharing with different ISPs



Loadsharing with different ISPs

- **Router A Configuration**

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.1 remote-as 100
 neighbor 122.102.10.1 prefix-list default in
 neighbor 122.102.10.1 prefix-list aggregate out
!
ip prefix-list aggregate permit 121.10.0.0/19
```

Loadsharing with different ISPs

- **Router B Configuration**

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 120.1.5.1 remote-as 120
 neighbor 120.1.5.1 prefix-list default in
 neighbor 120.1.5.1 prefix-list subblocks out
 neighbor 120.1.5.1 route-map routerD out
!
route-map routerD permit 10
 match ip address prefix-list aggregate
 set as-path prepend 130 130
route-map routerD permit 20
!
ip prefix-list subblocks permit 121.10.0.0/19 le 20
ip prefix-list aggregate permit 121.10.0.0/19
```

Loadsharing with different ISPs

- This example is more commonplace
- Shows how ISPs and end-sites subdivide address space frugally, as well as use the AS-PATH prepend concept to optimise the load sharing between different ISPs
- Notice that the /19 aggregate block is ALWAYS announced

Cisco Systems

BGP Multihoming

ISP/IXP Workshops